C1 Sub D1

1. (Three Times Amended) An illumination optical system having a total reflection type light transmitting element, for illuminating a surface to be illuminated, said illumination optical system comprising:

an imaging optical system for forming an image of a light source; and

a light directing optical system for directing light from the light source image to the light transmitting element, wherein light incident on the light transmitting element has a numerical aperture, at an entrance surface of the light transmitting element, which is smaller than a numerical aperture of light incident on said light directing optical system, at an entrance surface of said light directing optical system.

2. An illumination optical system, comprising:

an imaging optical system for forming an image of a light source by use of light from the light source;

a total reflection type light transmitting element; and

a light directing optical system for directing light from the light source image to said light transmitting element,

wherein the numerical aperture of said light directing optical system on the light transmitting element side thereof is smaller than the numerical aperture of said imaging optical system on the light transmitting element side thereof; and

wherein a surface to be illuminated by said illumination optical system is illuminated with light from the light source as transmitted by said light transmitting element.

3. An illumination optical system according to Claim 2, wherein the light source image has an illuminance which is larger in a portion adjacent an optical axis than in a peripheral portion about the optical axis.

4. An illumination optical system according to Claim 2, wherein said imaging optical system includes an elliptical mirror, wherein the light source is disposed at one focal point of said elliptical mirror, and wherein the light source image is formed at another focal point of said elliptical mirror.

5. An illumination optical system according to Claim 2, wherein the light source comprises a Hg lamp.

6. An illumination optical system according to Claim 2, wherein said imaging optical system includes first and second lens units having the same focal distance and being disposed so that a distance between principal points of the two lens units becomes equal to the focal distance, and wherein an entrance pupil of the first lens unit is disposed substantially in coincidence with the light source image while an exit pupil of the second lens unit is disposed substantially in coincidence with a light entrance surface of said light transmitting element.

7. An illumination optical system according to Claim 2, wherein said imaging optical system includes an optical rod and a lens unit, wherein a light entrance surface of the optical rod is disposed substantially in coincidence with the light source image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the optical rod, while another focal point position of the lens unit is disposed substantially in coincidence with a light entrance surface of said light transmitting element.

8. An illumination optical system according to Claim 2, wherein said imaging optical system includes fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the light source image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with a light entrance surface of said light transmitting element.

11. An illumination optical system for illuminating a surface to be illuminated, by use of an optical fiber bundle, said illumination optical system, comprising:

an imaging optical system for forming an image of a light source by use of light from the light source; and

a light collecting optical system for directing light from the light source image to the optical fiber bundle and being effective to make small the numerical aperture thereof.

12. An illumination optical system, comprising:

an imaging optical system for forming an image of a light source by use of light from the light source;

an optical fiber bundle; and

a light directing optical system for directing light from the light source image to said optical fiber bundle, wherein the numerical aperture of said light directing optical system on the optical fiber bundle side thereof is smaller than the numerical aperture of said imaging optical system on the optical fiber bundle side thereof;

wherein a surface to be illuminated by said illumination optical system is illuminated with light from the light source as transmitted by said optical fiber bundle.

13. An illumination optical system according to Claim 12, wherein the light source image has an illuminance which is larger in a portion adjacent an optical axis than in a peripheral portion about the optical axis.

14. An illumination optical system according to Claim 12, wherein said imaging optical system includes an elliptical mirror wherein the light source is disposed at one focal point of said elliptical mirror, and wherein the light source image is formed at another focal point of said elliptical mirror.

15. An illumination optical system according to Claim 12, wherein the light source comprises a Hg lamp.

16. (Amended) An illumination optical system according to Claim 12, wherein said imaging optical system includes first and second lens units having the same focal distance and being disposed so that a distance between principal points of the two lens units becomes equal to the focal distance, and wherein an entrance pupil of the first lens unit is disposed substantially in coincidence with the light source image while an exit pupil of the second lens unit is disposed substantially in coincidence with a light entrance surface of said optical fiber bundle.

17. An illumination optical system according to Claim 12, wherein said imaging optical system includes an optical rod and a lens unit, wherein a light entrance surface of the optical rod is disposed substantially in coincidence with the light source image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the optical rod, while another focal point position of the lens unit is disposed substantially in coincidence with a light entrance surface of said optical fiber bundle.

18. An illumination optical system according to Claim 12, wherein said imaging optical system includes a fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the light source image, and

wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with a light entrance surface of said optical fiber bundle.

19. An illumination optical system according to Claim 12, wherein said optical fiber bundle has a light entrance of one of square shape and rectangular shape, and a light exit face of arcuate shape.

20. An illumination optical system according to Claim 12, wherein said optical fiber bundle comprises a total reflection type fiber bundle.

21. An illumination optical system according to Claim 12, wherein said optical fiber bundle comprises a distributed refractivity type optical fiber bundle.

22. An illumination optical system, comprising:

light directing means for directing light to a predetermined plane, wherein the light includes plural light beams to be incident on the predetermined plane at different angles;

a total reflection type light transmitting element; and

a light directing optical system for directing light from the predetermined plane to said light transmitting element, wherein the numerical aperture of the light emitted from

said light directing optical system is smaller than the numerical aperture of the light impinging on the predetermined plane;

wherein a surface to be illuminated by said illumination optical system is illuminated with light from said directing means as transmitted by said light transmitting element.

23. An illumination optical system according to Claim 22, wherein said light transmitting element comprises an optical rod.

24. An illumination optical system according to Claim 22, wherein said directing means comprises a plurality of laser light sources.

25. An exposure apparatus, comprising:

an illumination optical system as recited in any one of Claims 1-8 and 11-24; and

a projection optical system for transferring, by exposure, a pattern of a mask as illuminated with said illumination optical system, onto a wafer.

26. A device manufacturing method, comprising steps of:

applying a resist to a wafer;

transferring, by exposure, a pattern of a mask onto the wafer by use of an exposure apparatus as recited in Claim 25; and